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ABSTRACT

Evidence and hypotheses concerning the relationships between health and nutrition factors in the family and fertility outcomes are examined in order to determine direct or indirect causal relationships. A review of evidence concerning the biological and behavioral effects of nutrition and health factors of fecundity and fertility, is followed by a description of an integrated model of relationships among nutrition, health, and intervals between birth in individual households. The model predicts changes in fertility that result from changes in nutrition and health, and illustrates statistical pitfalls in such research. Finally, an approach to understanding poor people's health and nutritional behavior, and the implications of the available evidence for choosing among modes of delivering health, nutrition and family-planning services is considered. Research questions which help to identify areas for intervention are also suggested. (CH)

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The Effects of Nutrition and Health on Fertility:
Hypotheses, Evidence, and Interventions

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July 1976

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The Effects of Nutrition and Health on Fertility: Hypotheses, Evidence, and Interventions

WILLIAM P. BUTZ AND JEAN-PIERRE HABICHT

The health and nutritional status of a population generally improves and fertility rates fall during the process of socioeconomic development. Similarly, the nations of the world exhibit in cross section a strong negative association between health and nutrition, on the one hand, and fertility on the other.¹ Clearly, these three are part of the interrelated processes of household and societal changes that occur during socioeconomic development. In this chapter we shall look at the evidence to determine to what extent relations among them are directly or indirectly causal, so that alterations in nutrition or health or the factors that influence them might be expected to alter fertility in a predictable direction.

We first examine the presumed *biological effects* of health and nutrition on fecundity and fertility. We also examine *factors influencing individual and family decisions* about nutrition and health which in turn affect fecundity and fertility. This information is then integrated into a simple model to predict changes in fertility that result from changes in nutrition and health and to illustrate some statistical pitfalls in research. We then consider the implications of the available evidence for choosing among modes of delivering health, nutrition, and family-planning services and suggest research questions whose illumination would help governments to choose among alternative interventions.

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¹ We define fertility in this chapter as the bearing of children. This demographer's usage differs from the medical definition as the capacity of a woman to have children. The latter we call fecundity.

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Review of the Evidence Concerning the Effects of Nutrition and Health Factors on Fertility

Nutrition and health may affect fertility directly through biological mechanisms in potential mothers or through behavioral linkages at the individual and family levels. Indirect linkages may also exist that have the effect of relating seemingly independent maternal characteristics or facets of behavior to fertility.

Biological Effects

Health and nutrition can affect a woman's fecundity by influencing the ages of menarche, menopause, and death, the success of each pregnancy, the duration of postpartum sterility, and her fecundity during the menstrual cycle.² There is no direct evidence at a population level that health or nutrition affects coital frequency or male fertility.

At the population level, maternal morbidity appears not to be a significant influence on fecundity.³ Nevertheless, there are historical instances of disease that appear to have lowered fecundity.⁴ A difficulty in

² In reviewing the biological evidence we concentrate on the association between nutrition and health and fertility, rather than on a discussion of the possible biological mechanisms underlying these associations. In addition, the effects of infant and child mortality on fertility and the causes of mortality are covered in chapter 8 and are only considered here insofar as they influence nutritional status and health. Furthermore, except where it is essential to do so, we do not discuss specific components of health and nutritional inputs and status or the way they are measured.

Finally, we are concerned with fertility as a dependent variable, not with its effects on health and nutrition outcomes. Joe D. Wray (1971a) affords the best survey of evidence on the effects of family size and spacing on children's mortality, morbidity, and physical and mental development. Wray (1975) indicates the possible effects of nutrition in these relationships in decreasing fertility. Samuel M. Wishik and Susan Van der Vynckt (1973, pp. 9-19), review the evidence concerning effects of birth spacing and family size on maternal and child nutritional status. Many studies reviewed in the three papers indicate substantial effects, but the relative importance of birth spacing, total number of pregnancies or births, and number of living children is rarely sorted out. Further, many of the statistical associations are laid to the presumption that a family with more children has less income (or food) per child than a similar family in the same community but with fewer children. This presumption ignores the productive value of children and the exclusion of that value from most statistics on family income in less developed countries.

³ Dugald Baird (1965, pp. 357-361) reviews the literature to that time concerning health status effects on fecundity.

⁴ R. H. Gray (1974) discusses possible effects of Ceylon's eradication of malaria on fertility. Peter Pirie (1972) discusses the relationship between disease and fecundity on some Pacific islands.

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interpreting those results, however, lies in an inability to separate changes in fecundity from changes in fertility. In times of stress caused by widespread disease, fertility might fall because of economic or social factors quite apart from changes in the population's fecundity.⁵

On the nutrition side, substantial evidence from animal and human clinical studies, as well as from time trends in human populations, points to earlier menarche (Frisch 1974) and later menopause in females from better-nourished populations compared with those from malnourished populations. In acute severe malnutrition the menstrual cycle is suspended.⁶ However, a more important amenorrhea is that occurring after pregnancy when ovulation is suspended for a period ranging from weeks to more than a year.⁷ Postpartum amenorrhea can be lengthened for many months by lactation.⁸ Better nutrition and health may also increase postpartum fertility, since better-nourished mothers appear to be slightly more fecund after menstruation begins again (Said, Johansson, and Gemzell 1974, Habicht and Delgado 1973). However, better maternal

⁵ Maternal health status can, however, affect the mother's response to pregnancy, the outcome of pregnancy, and the development of the infant. See Earl Siegel and Naomi Morris (1970) and Wishik and Van der Vynckt (1973, pp. 7-9).

⁶ In addition, Alan Berg (1973, pp. 38-39) and Wishik and Van der Vynckt (1973, p. 37) note the effects of nutritional anemias in some populations on IUD-retention rates and the potential role of nutritional supplements in supplying the additional vitamin A requirements of women taking oral contraceptives. The extent of contraceptive efficiency that might be gained through better nutrition is unknown, but it is likely that it is small in comparison to the effects on the use of contraceptives of alternative interventions discussed in this conference.

⁷ See, for example, John B. Wyon and John E. Gordon (1971), R. G. Potter et al. (1965), Alfredo Perez et al. (1971, 1972), Anrudh K. Jain et al. (1970), Habicht and Behar (1974), and E. J. Salber, Manning Feinleib, and Brian MacMahon (1966).

⁸ Over a range of lactation from several weeks to two years, three to five weeks of amenorrhea appear to result, on the average, from every two months of lactation. This relationship cannot be counted as reliable in individual cases, both because the variance of the estimated coefficient is large and also because a woman's first menstruation after a birth frequently follows ovulation: she can be fertile before she knows it. Nevertheless, in the aggregate, lactation appears to be a reasonably effective contraceptive for a year or so after birth. Beyond that time, its effectiveness diminishes rapidly. The biochemical mechanism responsible for this relationship is not known, but Habicht and Behar (1974) offer a hypothesis. Others [Jain et al. (1970), Perez et al. (1972), and Habicht and Behar (1974)] provide regression estimates of the effects of lactation on amenorrhea. Jain et al. and Perez et al. correct for age and parity. Still others (Salber, Feldman, and Hannigan 1968) report significant mother-specific components of amenorrhea from birth to birth, independent of the length of the period of lactation.

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nutrition also extends the period of lactation, other things being equal, and does so to such a degree that the duration of postpartum infecundity may in fact be extended rather than shortened by improving maternal nutrition (Habicht and Behar 1974).

Nutrition during lactation, however, is a negligible factor in the fall of fertility rates in developing countries, because breast-feeding, and therefore periods of postpartum infecundity, decreases rapidly with socioeconomic development. In fact, in early stages of development, the rapid declines in breast-feeding that have occurred in many societies may have resulted in higher fertility.⁹ These declines have in some cases undoubtedly contributed to infant and child mortality and reduced physical (and perhaps mental) development as well.

Finally, it is often hypothesized that malnutrition decreases the probability of a successful pregnancy by increasing the chances of early or late abortion. There is as yet no direct evidence in human beings of such a relationship.

The above evidence indicates that the reproductive function is well protected from nutritional insults and poor health. Hence, though fecundity generally increases with betterment of nutrition and health from dangerously low levels, the movement from moderate malnutrition and chronic morbidity to adequate nutritional and health levels is nearly always accompanied, or followed, by decreasing fertility.

Behavioral Effects

Since the biological links that are reasonably well substantiated generally point to a *positive* relationship between maternal health and nutrition and fertility, it is to behavioral factors that we must look to understand the *negative* relationship that is, in fact, observed. Certain of the biological relationships mentioned above can be presumed to be strongly influenced by behavioral factors. However, there is virtually no direct empirical evidence about these behavioral links.

Looking at the biological influences on intervals between births, we have concluded that maternal health and nutrition have little influence at the usual levels found in most populations. Lactation does affect the renewed onset of ovulation, however, and lactation will presumably be affected by the degree of a mother's desire and opportunities to be doing something else, or in economic terms, by the opportunity cost of her

⁹ To the extent that other contraceptive practices were substituted for lactation, fertility will not have increased. Alan Berg (1973, pp. 230-232) documents the recent decline in breast-feeding in Singapore and the Philippines. For most parts of the world, information comes mainly from anthropological observation.

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time spent in breast-feeding.¹⁰ There are no estimates of the effect of this opportunity cost of time on breast-feeding behavior; there are several clues, however. Sara B. Nerlove (1974) finds in a cross-sectional study of primitive cultures that the time between birth and the introduction of supplementary infant food has significant negative correlation with the participation of women in subsistence activities contributing to the food supply. This is an important clue but an indirect one, since no adjustment was possible for other economic and sociological variables probably correlated with work participation, occupation, and breast-feeding. Anrudh K. Jain (1968) and his associates (Jain et al. 1970) report estimates of the direct association between level of education and length of the lactation period and the association between these two variables and postpartum amenorrhea. In their sample of married Taiwanese women they find, after adjustment for age and parity differences, that more highly schooled women lactate less. In addition, size of community of residence is negatively associated with length of the lactation period in gross and partial regression analyses. The partial regression coefficients for the sample of all women are -0.204 for education and -0.167 for residence.

Although level of schooling and size of place of residence bear an uncertain relationship with opportunity cost of time in this sample, they are probably correlated positively. There is generally a larger supply of jobs outside the home in the labor markets in larger communities, and there is reason to think that the wages paid to educated workers in these jobs exceed the value of their marginal product in work at home. However, education and size of place of residence are generally correlated with many things other than the opportunity cost of a person's time—components of modernity, for example. The problems of isolating the causal effects of education conceptually and empirically are not so difficult here as in recent analyses of these effects on fertility, but the problems are nevertheless substantial.¹¹

The sparse evidence is thus consistent with the presumption of a negative relationship between lactation and the opportunity cost of the mother's time, but it fails to discriminate at all between this relationship and a host of associated possibilities. Since breast-feeding in this connection is a use of time, however, evidence concerning relationships between

¹⁰ This cost may include both economic and social components. The opportunity cost of time may be high because jobs are available that cannot easily be performed with an accompanying child or because enjoyable social activities are available with the same characteristic. In general, more jobs than social activities are probably incompatible with child care in the less developed countries.

¹¹ See chapters 5 and 6 of this volume.

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cost of time and other kinds of time use is pertinent. There is no doubt that, in many developing countries, higher wages paid for work outside the home induce higher rates of participation in those jobs and fewer hours spent at home by women.¹² On the average, higher wages should therefore induce less time spent in many particular home activities, since the total amount of time at home is reduced. Unless the income elasticity of derived demand for breast-feeding and the share of women's earnings in family income are large, a reduction of breast-feeding time in response to offers of higher wages outside the home is implied by this evidence on labor-force participation and hours of work. More direct evidence is lacking.

Just as a mother must decide whether to breast-feed or engage in another activity, she may also decide between lactation as a means of postponing the next pregnancy and other methods of family planning. It is known that mothers in many low-income cultures are aware, in general terms, of the contraceptive function of lactation.¹³ To the extent that they breast-feed in order to delay their next pregnancies, it is reasonable to expect them to substitute cheaper or more effective goods or services for their own time when such substitutes become available. The extent to which they do so is not known.

Similarly, mothers may decide between breast milk and other foods on the basis of their value to their children's health and development. The mother's decision to substitute other infant foods for her milk may depend on the cost of the substitute foods in relation to the cost of her time (Habicht, Delgado et al 1973). The decision may also depend on the quality of the alternative food and upon the parent's evaluation of the importance of the child's health.

Most parents everywhere value the health of their children for non-economic reasons, but it is reasonable to expect parents to devote more time and money to good nutrition and health care for their children in settings where such care is also expected to pay off economically—because healthier children do better in school and therefore earn more, or because high-paying jobs exist that require persons with strength or good mental development. Understanding the role of economic returns on investments in health and nutrition is important, not because these returns are more important quantitatively than noneconomic values (they probably are not) or necessarily because economic returns con-

¹² See chapter 10.

¹³ For example, Habicht and Robert Klein (1972) report that more than three-quarters of the mothers in four traditional rural Guatemalan villages believe that lactation postpones a new conception. In the absence of modern contraceptive devices, lactation is probably the main child-spacing mechanism.

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tribute to national income and economic growth. The reason is rather that many of the important determinants of the *economic* returns on health and nutrition can be affected by public policies aimed at increasing the incentives for care of health and nutrition and removing the stumbling blocks to popular participation in supply-oriented public programs. Alternatively, there is little theoretical or empirical guidance available concerning the way in which the level of parents' *affective* valuation of child health, or of any other child quality, can be systematically influenced by public policy.

Although we have no direct evidence concerning the nature of parental *responses* to changes in the value of investments in health and nutrition, there are scattered indications that the economic returns on these investments can be large. In an important paper, Marcelo Selowsky and Lance Taylor (1973) used two sets of data from Chile and one from the United States to estimate the effect of investment in childhood nutrition on adult earnings. Using weight (at different ages) of Chilean children as proxies for nutritional status, Selowsky and Taylor related this to the children's IQ. They then estimated the effect of adult IQs on earnings in a sample of Chilean workers and unemployed persons and predicted the IQs of adults from their IQs as children.¹⁴ Their results suggest that an increase of 10 percent in a child's weight generates an increase in measured child IQ of 5 to 6.5 points and that this effect remains when a rather comprehensive index of socioeconomic status is included in the regression. Further, a change of 10 percent in measured adult IQ is associated with a 6 to 7 percent increase in earnings.

In spite of the inclusion of a socioeconomic status index in the regressions, it is possible, as Selowsky and Taylor recognize, that the estimated associations may be due to some underlying common factor that influences nutrition and IQ test results separately. If this is the case, changes in nutrition alone may have no effect on IQ test results. However, this is the only study we know of to attempt to link child health or nutritional status all the way to adult earnings. A number of other researchers have investigated the strength of particular links in this chain, though rarely with close attention to probable biases introduced by the nature of their data and statistical methods. Many of these studies also suffer from not correcting for nonnutritional or nonhealth differences that are probably systematically related to both nutrition and health inputs and to the output measures of interest. To attempt a summary of this diverse litera-

¹⁴ The relationship between child and adult IQs was estimated from a U.S. sample. On the basis of an assumption about the effect of milk consumption on birth weight, Selowsky and Taylor then computed the rate of return on a milk supplementation program.

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ture, we can say that chronic mild to moderate malnutrition in infancy and childhood can stunt physical growth (Habicht et al. 1974), and small stature of women appears associated with low birth weight of their children (Habicht, Yarbrough et al. 1973); hence, malnutrition can have intergenerational effects. Severe malnutrition in infancy and childhood has more severe physical and morbidity effects and also harms mental development, which seems usually to escape permanent damage from mild to moderate malnutrition (Scrimshaw and Gordon 1968, Latham and Cobos 1971). The effect of malnutrition and illness of children on their subsequent adult absenteeism, agricultural productivity and earnings is not known (Oelhaf 1971, pp. 10-14; Weisbrod et al. 1973). Even the association of adult moderate malnutrition and illness with indexes of adult work performance is unstable from study to study.¹⁵

Finally, there is the possibility that many parents see the number of children they have and the health and development status of their children as substitutes for one another in yielding that which they value about children. We know nothing about the empirical strength of this tradeoff. It is known, however, that parents in many cultures act as if years of schooling per child and number of children were substitutes (see chapter 6). Good health, nutrition, and development are, like schooling, components of the "quality" of children. The presumption is that parents also trade these more difficult-to-measure attributes against numbers of children. If so, and if the tradeoff is substantial, public programs aimed at increasing the supply of inputs to health and nutrition could have considerable effectiveness in reducing fertility, as parents learn that their children live longer and are stronger, healthier, and perhaps more intelligent.

Research designed to estimate the magnitude of behavioral responses discussed in this section should take account of the existence of customs and social norms. The rapidity with which people change their behavioral patterns with respect to food and health depends on the strength of these norms as well as upon the amount of personal benefit or absence of loss that they stand to experience by changing. Indeed, in several

¹⁵ See James C. Knowles (1969) and D. H. Griffith, D. V. Ramana, and H. Mashaal (1971). Several studies have utilized cross-national aggregate data to evaluate the contribution of health to national income and economic growth. These studies suffer from the usual debilitating inadequacies of aggregate national data of these types from less developed countries. For example, see Walter Galenson and Graham Pyatt (1964), Wilfred Malenbaum (1970), Irma Adelman and Cynthia Taft Morris (1968), and Hector Correa and Gaylord Cummins (1970).

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studies, norms appear to exert independent influence on fertility behavior after personal and family characteristics are accounted for.¹⁶ As such, their nature and strength should be taken into account by investigators researching the lags that characterize behavioral adjustments to disequilibria.

In the course of time, however, norms are surely not independent of the factors that created the disequilibria. As adjustment occurs and families approach a different pattern of behavior related to food and health, the regularities that characterize their new behavior will again begin to take on a social life of their own in the form of new traditions and norms. If conditions continually change, new norms may not have a chance to form, unless they concern the process of adjustment to change itself. But where they do form, they are a result of objective factors in families' environments, even as they modify personal responses to changes in that environment. Hence the inclusion of community averages as proxies for norms in path or regression analysis may produce underestimates of the long-run effects of particular environmental changes on health, nutrition, or fertility behavior. However, in studying short-run effects—that is, the dynamics of adjustment—consideration of norms may be an important way of identifying lag structures.

A Simple Integrated Model of Household Interactions Among Nutrition, Health, and Intervals Between Births

In this section, we develop a model that includes the causal links indicated by the available evidence summarized in the previous section as most important.¹⁷ This exercise has the purposes of integrating this evidence and of illustrating the problems that arise from clinical or statistical research that neglects consideration of multivariate influences and jointly determined variables. The model is focused on determinants of closed intervals between births, having nothing to say directly about the age at onset of coitus or the total length of a woman's fecund period. Hence, we do not discuss here influences on the timing of the first birth or on completed family size. Alternative methods exist for measuring the variables in the model; some of these alternatives are discussed briefly at a later point. The basic symbols used are as follows: *C*, price of al-

¹⁶ Deborah Freedman (1963) found this phenomenon in a U.S. sample, and Richard Bruce Anker (1973) demonstrates it quite convincingly in rural India.

¹⁷ J. E. Austin and F. J. Levinson (1974) propose a conceptualization of relationships between nutrition and fertility that includes some of the links discussed below as well as several others.

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ternative contraceptive methods; H , health and development status of children; I , interval between births; L , length of lactation period; M , amount of health and medical care received; N_1 , current and past nutritional intake of the mother; N_2 , infant's nutritional intake from foods other than breast milk; F , length of time after birth before mother's next ovulation—that is, before she becomes fecund again; T , cost of time spent in child care; V , value of a healthy surviving child.

Let us assume, in equation 7-1, that within a maternal age-parity group the length of the current interval between births depends positively on the length of time between the previous birth and first subsequent ovulation: the longer the infertile period, the longer the interval, other

$$(7-1) \quad I = \delta(F, T, C, V, H)$$

things being equal. In addition, the higher the opportunity cost of the mother's time spent in child care, the more expensive to her is another child; hence, higher opportunity cost of the mother's time induces a longer interval between births, other things being equal.¹⁸ A high price of contraceptive methods and materials induces less use and therefore a shorter interval.¹⁹ And if the value of a surviving child is high, parents will have a child more quickly, other things being equal. In addition, if parents consider child health a substitute for numbers of children, the interval may also depend positively on the baby's health: other things being equal, a decision to invest more in the health of the child may imply a decision to invest less in additional children by delaying or omitting the next birth.²⁰

¹⁸ The assumption of a positive partial relation between the wife's opportunity cost of time and birth spacing in this model assumes that the income effect of the wife's earnings on desired birth spacing is relatively unimportant compared with the substitution effect. It also ignores the role of differential availability of substitutes for the mother's time—older children, other relatives, industrial child-care facilities—in conditioning the fertility effect of a change in the mother's opportunity cost. Further, it omits consideration of possible economies of scale in child care. If another baby means little additional work to the mother of a two-year-old, the mother may have the second baby in the presence of an opportunity outside the home that would otherwise induce her to delay. Empirical analyses of birth spacing should account for these additional effects. The last two, concerning availability of child-care substitutes and scale economics in child rearing, would become central in a dynamic model of birth spacing.

¹⁹ The concept of "price" includes such factors as inaccessibility, inconvenience, and ineffectiveness. A contraceptive method obtainable no closer than 10 miles that produces inconvenient and unreliable protection has a high price in this framework. The prices of other goods and services in this model are defined in similarly broad terms.

²⁰ The conditions for such a tradeoff in a model of parental decisions about the quality and quantity of their children are discussed in chapter 6.

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The sign of these hypothesized causal dependencies can be simply indicated by partial derivatives. For example, the partial derivative of length of interval between births with respect to length of postpartum infecundity, $\frac{\partial I}{\partial F} \equiv \delta_F > 0$. Similarly, $\delta_T > 0$, $\delta_C < 0$, $\delta_V < 0$, and $\delta_H > 0$.

The baby's health and development status, H , depends, in equation 7-2, upon how long it is breast-fed, L ; how much nutritional intake it receives from other sources, N_2 ; the value of a healthy surviving child, V (the higher the value, the more parents will decide to invest in their child's health); and the amount of health and medical care it receives, M .

$$(7-2) \quad H = \beta(L, N_2, V, M)$$

where $\beta_L > 0$, $\beta_{N_2} > 0$, $\beta_V > 0$, and $\beta_M > 0$.

In addition, the length of time a mother lactates during the current interval, L , depends, in equation 7-3, on her current and past nutritional intake, N_1 ; her baby's nutritional intake from other foods than breast milk, N_2 ; the opportunity cost of her time spent in child care, T ; the value to the couple of a healthy surviving child, V ; and the price of alternative contraceptive methods, C .²¹

$$(7-3) \quad L = \alpha(N_1, N_2, T, V, C)$$

The partial effect of the mother's nutritional intake on the length of her period of lactation, $\frac{\partial L}{\partial N_1} \equiv \alpha_{N_1}$, is expected to be positive. On the other hand, the amount of other food the baby eats substitutes for mother's milk, so that $\alpha_{N_2} < 0$. The higher the opportunity cost of the mother's time in child care, that is, the more she values her time spent in other ways, the less time she chooses to breast-feed, so that $\alpha_T < 0$. The partial effect of the value of a healthy surviving child on the parents' desired length of the period of breast-feeding is positive, $\alpha_V > 0$, since the higher the value the greater is their incentive to contribute to the child's health. Other things being equal, a couple having inexpensive access to alternative effective methods of contraception will choose a shorter lactation period, $\alpha_C > 0$.²²

²¹ In a fuller treatment, a variable indicating the death of a nursing child would be included as a determinant of lactation. However, this variable is treated in chapter 8.

²² Lactation is a physiological process while breast-feeding is a behavioral phenomenon. While it is possible for a woman to continue lactating without feeding the milk to her child, in our example we may consider lengths of the periods of lactation and breast-feeding to be equivalent.

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Finally, the length of time after the baby's birth before the mother has her first ovulation and becomes fertile again, F , depends positively, in equation 7-4, on the length of time she breast-feeds, L , and negatively on her current and past nutritional intake, N_1 .

$$(7-4) \quad F = \gamma(L, N_1)$$

where $\gamma_L > 0$, and $\gamma_{N_1} < 0$, since better nutrition speeds the return of ovulation, holding length of breast-feeding constant.

These four equations constitute a simple model of biological and behavioral influences on intervals between births.

By differentiating the equations totally and substituting the expressions for left-hand-side variables into the right-hand sides of other equations, a set of expressions relating changes in each of the model's left-hand-side variables dL , dH , dF , and dI , to changes in the other variables results. For our purposes, the equations explaining changes in length of postpartum sterility, lactation, and child's health are of less interest than the one characterizing changes in length of the interval between births:

$$(7-5) \quad \begin{aligned} dI = & (\delta_F \gamma_L \alpha_{N_1} + \delta_F \gamma_{N_1} + \delta_H \beta_L \alpha_{N_1}) dN_1 \\ & + (\delta_H \beta_{N_2} + \delta_H \beta_L \alpha_{N_2} + \delta_F \gamma_L \alpha_{N_2}) dN_2 \\ & + (\delta_H \beta_V + \delta_H \beta_L \alpha_V + \delta_F \gamma_L \alpha_V + \delta_V) dV \\ & + (\delta_F \gamma_L \alpha_C + \delta_H \beta_L \alpha_C + \delta_C) dC \\ & + (\delta_T + \delta_H \beta_L \alpha_T + \delta_F \gamma_L \alpha_T) dT \\ & + \delta_H \beta_M dM \end{aligned}$$

The behavioral and biological relationships specified in equations 7-1 through 7-4 are obviously extremely simplified. On the behavioral side, family wealth and income are not factors, and the opportunity cost of the mother's time is assumed to be unimportant in affecting her baby's health and development. Among the potential biological links omitted are effects of mother's health and development status on her lactation and the characteristics of the baby's environment *in utero* on its health status. However, even in this simple specification only one variable, medical and health care (dM in the last line of the equation), has an unambiguous effect on the interval between births in equation 7-5—the derivative is positive. The effects of changes in all other variables are ambiguous, a priori, depending on the relative magnitude of direct and indirect effects throughout the system. As an example, from the second

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line of equation 7-5, consider the effect of an increase in the baby's nutritional intake from sources other than breast milk:

$$(7-6) \quad \frac{dI}{dN_2} = \delta_H(\beta_{N_2} + \beta_L\alpha_{N_2}) + \delta_F\gamma_L\alpha_{N_2}$$

The first term on the right side of the equation, δ_H , reflects the tendency of the couple to want fewer children and longer intervals between them if their existing baby is healthier. Whether the baby is healthier or not as a result of the feeding change is uncertain, however. On the one hand, β_{N_2} is positive, representing the healthful effect of additional nutrients in the baby's diet, other things being held constant. On the other hand, $\beta_L\alpha_{N_2}$ is negative, reflecting the diminution of health that results from the lessened breast-feeding that accompanies increased volume elsewhere in the baby's diet. The last term, $\delta_F\gamma_L\alpha_{N_2}$, represents the shortened interval between births induced by reduced lactation as the baby substitutes other food for mother's milk.

Considering all factors together, the interval between births is shortened because of supplemental feeding if the supplement has little or negative value in promoting the baby's health and development, as might be the case with water or contaminated animal milk. For in this case, β_{N_2} is small, zero, or negative, reflecting the supplement's low value, but α_{N_2} within the parentheses remains at nearly the same level regardless of the nutritional and hygienic quality of the supplement, since the substitution of other food for breast milk depends mainly on the quantity of other food rather than its quality. Hence with small β_{N_2} , the entire first term is negative. Since this substitution effect embodied in α_{N_2} also shortens the period of sterility and thereby shortens the interval between births, as represented in the last term on the right side of equation 7-6, the smaller the health- and development-producing effect of the supplement in relation to its effect in shortening the period of lactation, the more reduction is expected in the interval between births in response to supplementary feeding. On the contrary, of course, a hygienic and highly nutritious supplement may lengthen the interval if it increases child health and development sufficiently (β_{N_2}), and if parents are satisfied in this situation to have fewer children, and thereby delay (or omit entirely) their next pregnancy (δ_H).

To carry this example a bit further, the relative importance of the terms in equation 7-6 also depends on the child's age when the supplement is begun. After four to six months of age, β_L declines if there are any other foods with protein and caloric content in the diet. After twelve months or so, the child's nutritional requirements have outgrown

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the ingredients of mother's milk sufficiently so that β_L may be quite small indeed, with β_{N_2} having grown correspondingly. At the same time, γ_L decreases as the marginal capacity of lactation to delay ovulation declines after eighteen to twenty-four months of lactation. Hence, as the child grows older, failure to feed it food other than breast milk may induce shorter intervals between births as parents rush to have another child to supplement (or possibly replace) their sickly baby even as the sterility effects of lactation come to an end.

Consideration of the effects of another variable in equation 7-5 will lay sufficient groundwork for our later discussion of the difficulties of measuring the variables. The effect of an increase in the opportunity cost of the mother's time in child care, T , on the interval between births is also ambiguous a priori. From the fifth line of equation 7-5,

$$(7-7) \quad \frac{dI}{dT} = \delta_T + \delta_H \beta_L \alpha_T + \delta_F \gamma_L \alpha_T$$

The first term on the right side of equation 7-7, δ_T , is positive, representing the longer spacing between births that the couple is expected to choose in response to the increased price of an important input in child rearing, the mother's time. The second term on the right side, $\delta_H \beta_L \alpha_T$, is negative, since the mother's lessened lactation in response to an increased opportunity cost of her time results in a less healthy child and a consequent desire to have another child sooner. The third term on the right side, $\delta_F \gamma_L \alpha_T$, is negative, reflecting the fecundity effect of the mother's lessened lactation. In sum, therefore, an increase in opportunity cost might lengthen or shorten the interval between births. The net effect depends on the relative strength of behavioral factors and the biological effects that they induce.

The model we have considered is simple and illustrative, necessarily omitting some variables and interactions of potential significance. One such variable is family income, and the interaction is intergenerational. Equation 7-4 in our model embodies a hypothesis that parents consider child health and development to be a substitute for having another child quickly. In addition to this substitution effect, child health may also have an intergenerational influence on the spacing of births and on completed fertility by affecting the future market income and home productivity of the next generation. If early investment in a child's health and nutrition produces a stronger or more intelligent person who performs better in school and earns a higher lifetime income than he might otherwise, his higher income may induce a fertility effect. In addition, if early investments in the nutrition and health of girls increase their productivity

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in caring for their own children, other kinds of fertility effects may result.²³

An Approach to Understanding Poor People's Health and Nutritional Behavior

Theodore W. Schultz (1964) has suggested that the investment behavior of persons in traditional agriculture corresponds closely to what economic theory would predict for producing units in long-run economic equilibrium. With little change for generations in available tools, seed, and other types of productive capital, traditional farmers have learned through trial and error the optimal allocation, through space and time, of human and other resources to yield maximum income. The present values of all investments are equated at zero; opportunities for producing more with the resources at hand are exhausted. The studies cited by Schultz and the econometric evidence accumulated since then constitute a convincing case for the hypothesis.

Among policy implications that Schultz drew from this hypothesis is the proposition that technical assistance concerning cropping patterns, land management, and care of animals will not succeed. Generations of experience under unchanged conditions have produced more expertise in the fields than in the colleges, at home or abroad. In addition, increasing the flow of information about where and when to buy the traditional inputs and how to use them will have no effect. It is already known. Instead, Schultz suggested, *new* inputs must be supplied. If the new inputs were profitable when used in conjunction with the farmer's existing human and physical resources, and if their profitability were demonstrated to farmers, then farmers would adopt them. The creation of disequilibria, therefore, is the key to agricultural growth.

Similarly, we suggest that the patterns of disposition and consumption of food actually observed in many rural, traditionally low-income environments may correspond closely to the pattern predicted by economic theory under the following conditions: Available jobs for children and adults require little intellectual activity, since optimal production allocations have long since become community traditions known to all; an underdeveloped capital market makes relatively attractive the buying

²³ These productivity effects are formally analogous to the home-productivity effects of education analyzed by Robert T. Michael (1973b). Discussion of the effects of income on fertility is in chapter 2, while chapters 9 and 10 deal with issues related to women's work and time use and their fertility.

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and selling of animals as noncash stores of value from harvest to planting; productive requirements for physical strength are highly seasonal, peaking perhaps two or three times a year, but at a low level otherwise.

Under these conditions an optimal allocation of resources gives much food to persons having the highest value of marginal product in production, generally the men, and little to persons having the lowest marginal product, children. This procedure maximizes production and general purchasing power; in the process it may reduce the future health and development of children somewhat, but the return on these investments is small. Further, this optimal allocation of resources gives an even larger share of the available food to the most productive workers during seasonal peaks in labor requirements. This allocation is most striking when it is coupled with food scarcity before the harvest, when it causes some members of the family to go hungry. Throughout the year, some nutritious food, even corn and tomatoes, is fed to the hogs or the bullocks instead of to the children, since keeping the animals healthy assures next season's seed money, perhaps with capital gains, while keeping the children healthy brings only long-term dividends and perhaps not large ones at that.²⁴

The policy implications of this approach are very different from those associated with the contending approach at the other extreme, the "backward peasant" model. In the final section of the chapter we shall outline the differences.

Implications for Programs

To this point we have examined evidence and hypotheses largely concerning linkages at the family level between health and nutrition factors, on the one hand, and fertility outcomes on the other. Perhaps equally important are issues concerning economic, institutional, and bureaucratic factors that affect the relative desirability of alternative modes of delivering health and nutrition services to families. The issue here on the supply side that has received most attention concerns program-level integration of either nutrition and family-planning services or health and family-planning services, or of all three. Such integration has been called for since World War II by influential researchers, planners, and

²⁴ This picture is quite consistent with parental love for children. Children need housing, clothing, and other things as well as food, and these things can be produced or purchased in greater amounts if resources, including food, are allocated so as to produce a higher family income.

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international institutions.²⁵ We review here the arguments for such integration and the weight of scientific evidence, such as it is.

The arguments often advanced for such integration include the following:²⁶

1. If modern family planning methods are the first nontraditional input introduced into the community, reluctance to try them and continue their use might be overcome by delivering at the same time health care, the results of which can be quickly seen (Taylor 1965, p. 478; Taylor and Hall 1967, p. 655; Berg 1973, pp. 35-37).
2. If the family planning methods being supplied require continuing health or nutrition services, delivery of the first without the second is inefficient.
3. Since the spacing of births can affect both maternal health and child morbidity and mortality, a family-planning component can contribute to the success of health and nutrition programs.
4. Since good child nutrition and health tend through behavioral responses to lengthen the intervals between births, nutrition and health components can contribute to the success of a family-planning program.
5. Since the primary target populations—pregnant and lactating women with young children—are the same, there are economies of scale in delivering all desired services in as few visits as possible.
6. The personnel who deliver health, nutrition, and family-planning services require similar training and attributes; there are thus economies to be realized from having the same person do more than one job.
7. There are other economies of joint production at the local or national level arising from bulk purchasing or joint administration.
8. In some situations, one program cannot be approved at the national level without justification in terms of a separate but related goal. In these cases, as perhaps when there is a Ministry of Health but none of family planning, program integration may be a solution.

The first four reasons depend on assumptions about the nature and strength of biological and behavioral interactions. If the characterization of the family discussed in the preceding section and the role of norms outlined earlier are useful conceptualizations, the first reason in this list makes sense. The crucial assumption is that parents *want* their children

²⁵ The World Health Organization and Pan American Health Organization are among the institutions. See Pan American Health Organization (1970).

²⁶ Others [Wishik (1972, pp. 5-8), Wishik, Thomson, and Habicht (1972, pp. 23-25), Austin and Levinson (1974), and the National Academy of Sciences (1975)] discuss many of these points in more detail.

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spaced or want fewer children. The second reason is true in the case of the IUD and the pill. The truth of the assumption underlying the third reason has not been strongly demonstrated, in our opinion. Research has not been successful in separating effects on health of the spacing of births from the effects of total number of pregnancies and children and from the effects of other factors associated with maternal age, fertility patterns, and health. The correlations are strong, but causality is much less certain. The evidence concerning the fourth presumption is weak but suggests that it is a quantitatively important phenomenon. The fifth reason rests on an obviously true presumption, while the last three reasons are important wherever they apply. Only evidence bearing on reasons one and four is reviewed in this chapter. The evidence on these points is sparse and largely circumstantial, but it tends to support the arguments.

Nevertheless there are cases where family planning has apparently been successfully offered without nutrition and health services, just as successful cases of integrated delivery exist (Taylor and Hall 1967, pp. 655-656; but see Wishik and Van der Vynckt 1973, pp. 28, 30-32). Several large demonstration projects—one in Narangwal, Punjab, India (Oelhaf 1971, pp. 37ff.), and one in Danfa in Africa (UCLA School of Public Health 1972)—that feature treatment communities with various combinations of family-planning materials, family-planning information, and health services, have been operating for more than four years. These projects have considerable promise in sorting out the importance of the various effects hypothesized to justify joint program delivery. To achieve this goal, however, will require more attention than biomedical research has heretofore devoted to the role of *behavioral* relationships linking health, nutrition, and fertility behavior in the family. Otherwise, inferences from correlations to causality may not be possible, and the identification of particular causal factors that should be considered or replicated in other settings will be hindered.

Required Research for Selecting Intervention Points

The available evidence is insufficient in most settings for choosing among alternative interventions on grounds of cost and effectiveness. The costs of some interventions—particularly programs of public health and nutrition—have been carefully measured, but estimates of their benefits are often flawed. For most others, the order of magnitude of neither costs nor benefits is known.²⁷ Ranking the alternatives in terms of political

²⁷ However, Schlomo Reutlinger and Marcelo Selowsky (1975, pp. 27-44) developed formulas to measure the cost and effectiveness of food price sub-

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feasibility is an easier job and has of course been done in countries in which particular policies were being considered (Berg 1973, pp. 241-247).

In the area of nutrition, the public and private *supply* systems that link together agricultural production, transportation, and marketing are ill understood in most of the less developed countries. Potential bottlenecks have rarely been identified.²⁸ For both nutrition and health, even the most basic parameters that characterize family *demand* for foods and health care and the allocation of these goods among family members have only rarely been estimated for the less developed countries. Yet it is these behavioral relationships that transform public policy changes in other areas into often unintended health and nutrition effects and that may constrain the effectiveness of many public programs.²⁹

The gains from additional understanding of pertinent economic and social relationships on the supply and demand sides appear to be much greater than the gains from additional biomedical research on biological links in the system. This conclusion need be based on only one fact: the biological effects of better health and nutrition are primarily to increase fecundity and therefore fertility. Yet except in states of severe morbidity or malnutrition, higher levels of health and nutrition of a population are accompanied by lower fertility (often with a lag). Nonbiological links predominate. In spite of these clear gross relationships, it was demonstrated earlier that considerably more systematic knowledge has been accumulated concerning biological linkages than concerning behavioral ones.³⁰ This imbalance results partly from the fact that biological systems appear more regular and less complex than socioeconomic systems, in the light of the knowledge available at present. But it is also because

sidies, income transfers, and food stamp programs. Simulation of their formulas with alternative values of elasticities of demand and supply of food strongly suggests that programs oriented toward target groups are considerably more cost-effective than a general price subsidy. This important paper contains a number of other conceptual and empirical insights concerning the distribution of nutrition in less developed countries and the returns on alternative policy approaches.

²⁸ Work undertaken by nutritionists, economists, and operations researchers in the Applied Nutrition Division of the Institute for Nutrition of Central America and Panama (INCAP) shows promise in developing appropriate methodologies for studying supply systems in Central America.

²⁹ A principal conclusion of a PAHO working conference on the economics of malnutrition was that "the major unfilled data and methodological limitations are in the household system. Preferred intervention points depend heavily on knowledge of the determinants of individual behavior" Popkin (1972, p. 6).

³⁰ Wishik and Van der Vynckt (1973, pp. 49-50), outline needed physiological and biological research on nutrition-health linkages.

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relatively little research money has gone to social scientists interested in studying health-nutrition-fertility relationships, and of that, almost nothing has gone for the study of the crucially important demand factors.

If more money *will* be spent in these areas, how should it be allocated? The following research subjects focus, in our opinion, on the crucial links in the supply and demand networks that determine the level and distribution among persons and families of stocks of nutrition and health and the effects of these stocks on fertility outcomes:

- Determinants of the earnings and agricultural productivity effects of investments in the health and nutrition of children. This basic quantitative knowledge about V , the value of a healthy surviving child, is necessary for estimating family demand for health and nutrition inputs and for studying parental tradeoffs between numbers of children and "quality" of children (equation 7-1).

- Economic and social determinants of intrafamily patterns of food distribution. These patterns are the proximate determinants of N_1 and N_2 , the nutritional intake of mother and child, respectively. Descriptive data on these patterns are needed to investigate the explanatory power of the approach suggested earlier.

- Determinants of the income and price elasticities of demand for preventative and curative health care among disadvantaged groups. These elasticities are the basic parameters characterizing the demand for health care, M . Knowing their magnitude permits prediction of the effects on health care of changing prices and family income. Understanding their determinants shows intervention points at which family demand can be raised.

- Determinants of the income and price elasticities of demand for nutritious foods among disadvantaged groups.³¹ Knowledge about these elasticities of demand for nutrition, N_1 and N_2 , is important for the same reasons as in the case of health care, above.

- Determinants of patterns of parental substitution between numbers of children and "high-quality" children of superior health and nutritional status. This knowledge of the sign and magnitude of the coefficient of H , in equation 7-1, is important for understanding parents' fertility responses to changing incentives for health care and nutrition.

³¹ The high share of expenditure going to food and relatively high income elasticities of demand for most kinds of food among poor people generally give increased income a strong effect on the amount and type of food consumed. Yet the foods subject to highest income elasticities are not necessarily the most nutritious, since food can have taste-satisfying and status-augmenting functions as well. Therefore, higher family income does not necessarily lead to better nutrition.

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- Economic and social determinants of the mother's breast-feeding behavior, characterized by the child's age at the first introduction of other food and the length of the lactation period. Having estimates of the parameters of equation 7-3 will facilitate understanding of the reasons for declines in breast-feeding during socioeconomic development and may point to interventions useful in stemming this decline.

None of these subjects approaches being a complete study of the potential cost and effectiveness of particular policies in influencing fertility, or health or nutrition. In general, understanding of the particular components of the relevant systems is still rudimentary and does not justify putting the pieces together and looking for internal tendencies and inconsistencies. First, we must know more about the signs and magnitudes of particular parameters. Most of these recommended research areas also deal with household demand phenomena, and therefore more with influences on the effectiveness of public programs than with their costs. This bias comes from a presumption that ranking effectiveness is a prior task. Policy makers can then select among those environmental changes that will work, on the basis of cost considerations.

Some of these research areas could undoubtedly be illuminated with existing nutrition and health surveys.³² Others will require household-level data that describe a wider range of family members' activities.³³ Nearly all could be profitably investigated through the vehicle of demonstration experiments that alter particular features of the environment in order to study patterns of direct and indirect effects.³⁴

Aspects of Estimation, Inference, and Measurement

Research in the biological and social sciences related to health, nutrition, and fertility has frequently produced results with misleading implica-

³² This process is needlessly hindered when bodies of survey data are impounded for years by their collectors, or by the agencies that supported the collection. After a reasonable period of exclusive use to ensure incentives for competent researchers to collect data, all survey data gathered at the expense of public institutions should be released into the public domain, where social returns from additional research can accrue.

³³ Two such data sets are being collected by the Rand Corporation and the Division of Human Development, Institute for Nutrition of Central America and Panama (INCAP), in Guatemala, and by Rand and the Department of Statistics, Government of Malaysia, in Peninsular Malaysia. General characteristics of the required data are summarized in Butz (1972, pp. 40-46). Wishik and Van der Vynckt (1973) also discuss desirable features of survey data sets in this area.

³⁴ Only long-run and intergenerational responses are impossible to investigate in a short-run experiment. In the absence of intergenerational panel data, these effects must be studied in cross-sectional data sets.

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tions, if any, for policy makers. Analysis of the particular research topics listed above and of other related topics would benefit from consideration of several methodological points.

For example, in the problem addressed in this chapter, the relationship between the length of the lactation period and the duration of postpartum amenorrhea or sterility has been examined in a number of clinical and field studies.³⁵ We can investigate the implications of a common approach to this problem by looking at equation 7-8, derived from equations 7-1 through 7-4, which relates a change in the period of sterility to a change in the length of the period of lactation.

$$(7-8) \quad dF = \gamma_L dL + \gamma_{N_1} dN_1$$

where

$$\gamma_L dL = \gamma_L \alpha_{N_1} dN_1 + \gamma_L \alpha_{N_2} dN_2 + \gamma_L \alpha_T dT + \gamma_L \alpha_V dV + \gamma_L \alpha_C dC$$

The most common analytic procedure in these studies is to compute the gross correlation between the length of the period of lactation and the period of amenorrhea or sterility.³⁶ The analogues in our model are a correlation between changes in these variables, or an estimation of the coefficient γ_L in a regression of dF on dL . If the model of equations 7-1 through 7-4 is specified correctly, this simple procedure leads to an underestimate of the direct causal relationship between lactation and amenorrhea as long as $dN_1 \neq 0$. For, in this case, there is a direct determinant of amenorrhea, namely, the mother's nutritional intake, that independently and negatively ($\gamma_{N_1} < 0$) affects the length of the period of postpartum sterility.

Neglecting to take statistical account of this part of the relationship causes the gross correlation between L and F to include the negative direct effect of dN_1 in addition to the positive effect, α_{N_1} , operating indirectly through lactation. Therefore, the simple correlation between F and L is an underestimate of the true causal relationship between lactation and postpartum sterility.³⁷

The relationships in this simple example are purely biological. The problems would be compounded by estimating a gross correlation be-

³⁵ Ovulation need not begin prior to the first postpartum menstruation; anovulatory cycles are possible. Hence the interval between a birth and the mother's first subsequent menstruation may be shorter or a little longer than her period of postpartum sterility.

³⁶ The model in our example is deterministic. The simplest stochastic specification would add random error terms to equations 7-5 and 7-8 and other estimating equations.

³⁷ For a general treatment of omitted-variable bias, see Theil (1971, pp. 548-550).

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tween the length of the period of lactation and the interval between births. Isolating the terms in equation 7-5 that involve lactation responses gives

$$(7-9) \quad dI = (\delta_F \gamma_L + \delta_H \beta_L) dL + \delta_F \gamma_{N_1} dN_1 + \delta_H \beta_{N_2} dN_2 \\ + (\delta_V + \delta_H \beta_V) dV + \delta_C dC + \delta_T dT + \delta_H \beta_M dM$$

where $(\delta_F \gamma_L + \delta_H \beta_L) dL$ is the collection of effects that operate through the lactation variable,

$$(7-10) \quad (\delta_F \gamma_L + \delta_H \beta_L) dL = (\delta_F \gamma_{L\alpha_{N_1}} + \delta_H \beta_{L\alpha_{N_1}}) dN_1 \\ + (\delta_F \gamma_{L\alpha_{N_2}} + \delta_H \beta_{L\alpha_{N_2}}) dN_2 \\ + (\delta_F \gamma_{L\alpha_V} + \delta_H \beta_{L\alpha_V}) dV \\ + (\delta_F \gamma_{L\alpha_C} + \delta_H \beta_{L\alpha_C}) dC \\ + (\delta_F \gamma_{L\alpha_T} + \delta_H \beta_{L\alpha_T}) dT$$

The simplest relationship that can be estimated is the gross correlation between L and I , or between changes in L and changes in I . The latter, or estimation of the reduced-form coefficient $(\delta_F \gamma_L + \delta_H \beta_L)$ in a regression of dI on dL , is more conveniently discussed in the framework of our model. From equation 7-9 it is apparent that this procedure yields a biased estimate of the true causal relationship.³⁸

These two examples illustrate the importance of prior conceptual modeling and appropriate statistical methodology in estimating the magnitude of causal links between health, nutrition, and fertility variables at the family level.³⁹ Beyond these considerations, a researcher interested in deriving information useful for the formulation of policy would presumably seek to sort out the causal effects of variables in equation 7-5 that are amenable to policy manipulation aimed at changing fertility. Among these might be N_1 , N_2 , V , C , and T , depending on the social, economic, and political characteristics of the setting. The length of the lactation period itself is a less likely candidate, since the institutional and political tools required to influence women's behavior in this sphere directly are generally lacking.

³⁸ Components of this bias disappear if any of the coefficients on the right side of equation 7-10 are zero or if any of the coefficients on the right side of equation 7-9, except the coefficient of dL , are zero. Health and medical care, M , is not a component of dL , so that ignoring it does not bias the simple correlation or regression coefficient.

³⁹ These examples do not take up the common and important problem of joint determination resulting in simultaneous-equation bias. For discussion of this topic related specifically to economic and demographic household models, see Butz (1972, pp. 11-25), and T. Paul Schultz (1974, pp. 22-31).

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Faced with this policy-oriented task, the researcher would err in running a regression, based on equation 7-9, that included lactation time explicitly as an explanatory variable. This procedure would bias the coefficient estimates corresponding to the other variables, in some cases causing them to overestimate the true causal influence. This means, for example, that the estimated coefficient δ_c , in equation 7-9, is less than the total reduced-form coefficient ($\delta_c + \delta_{FYL\alpha_C} + \delta_{H\beta L\alpha_C}$), reflecting all effects of the price of contraceptives on the length of the interval between births. If the price of an ineffectual contraceptive were to be lowered, intervals between births could actually become shorter if women reduced their lactation periods as a result—especially if shorter breast-feeding significantly hindered the health and development of their children. Yet the partial effect, δ_c , is all one would catch by regressing dI on both dC and dL in such an equation as 7-9. More generally, a regression based on equation 7-9 would yield estimates of the effects on the interval between births of changes in the value of children and the price of contraceptives that are biased in a negative direction from the true total effects to be expected. A policy effecting a reduction in the value of children or the price of contraceptives would not actually engender so large an increase in the interval between births as the estimated regression coefficients would indicate. Similarly, an estimate in equation 7-9 of the relation between changes in the opportunity cost of the mother's time and changes in her interval between births would appear more positive than the total association actually is.

In the case of maternal and child nutrition, their causal influences on intervals between births can be consistently estimated in the framework of equation 7-5. Even if estimates of this kind existed, however, they might not be useful in many policy situations. To change maternal and child nutrition themselves is a complex task, about which far too little is known, in spite of much research.⁴⁰ The required research for policy purposes should be based on models of food intake as a function of determining factors *amenable to public policy*. A simple economic model for constructing such an analysis might be $N_1 = \epsilon$ (prices of available foods with high nutritive content;⁴¹ prices of available foods with low nutritive content; the productive value of good nutritional status in agricultural and labor-market work; household income; mother's level of schooling; characteristics of advertising or other information inputs about the nutritive values of different foods).

⁴⁰ Wishik (1972) has pointed out that "the implications of intimacy and depth of affect associated with one's sexuality are probably exceeded only by one's protectiveness about food likes and preferences. Nutritionists can well believe that sex behavior may be easier to change than eating habits."

⁴¹ Recall our broad definition of "price," in footnote 19.

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Such an input-demand function could be derived from a structural model of behavioral-biological interactions, such as equations 7-1 through 7-4, with the addition of a utility function and another equation representing the couple's budgetary constraint. Alternatively, sociological and social-psychological theory would suggest other specifications. The important thing, in any case, is to concentrate on those explanatory variables amenable to change by instruments of policy.

Joint estimation of specifications based on equation 7-5 and the relationship determining N_1 would yield predictive relationships connecting the prices and availabilities of nutritious foods, perhaps supplements, to the length of intervals between births. Such a grand scheme can well await careful estimation of the magnitudes of separate crucial links in that long chain, however, since several may be extremely weak in many settings. Little of this groundwork has been laid.

A related methodological consideration concerns evaluation of public health programs that change environmental factors requiring no individual behavioral responses in order to affect health and nutrition but in which behavior can affect the outcome. Cleaning up the public water supply or adding fluoride, giving free inoculations at school, and instituting mosquito control against malaria have been common examples in low-income countries. Two virtues of these programs are that they can be administered directly as part of public policy and that their effects occur without response (or even necessarily knowledge) on the part of the target population. Furthermore, their effects are relatively easily evaluated with simple control-group designs. The only difficulty, and one not frequently recognized, is that evaluation should account for changes in composition of the target populations. The in-migrant group will in general contain a disproportionate number of persons who value the public health input and substitute it for goods and services that they purchased previously. Their posttreatment health status is high, but it may also have been high before the treatment began. These in-migrants will also tend to use the nutrition and health services more, so that the amount of services provided will also rise, again with no improvement in actual health, nutrition, or fertility. A solution to these biases lies in identifying cohorts which can be followed for the duration of the study.

It should be obvious that direct measures of health, nutrition, and fertility are more significant than measures of health services given, gallons distributed, or contraceptive pills dispensed. It is also evident that better health and nutrition inputs will not improve the health and nutrition of the healthy and well fed. Nevertheless, these obvious facts are neglected in the design and interpretation of many studies.

As pointed out above, we deal with interactive systems when we deal with health, nutrition, and fertility—the human body as a biological

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system, the family and community as economic and social systems. Changes in one part of a biological or economic system have, in general, both direct and indirect effects in other parts. Estimates of the effect of a change in one variable upon the value of another variable may be biased if important indirect links connecting the two variables are improperly handled or if other factors that change simultaneously are not accounted for in the analysis. In general the complexity of biological and social systems precludes a complete accounting of these links in theory or estimation, but it is incumbent upon researchers to utilize conceptual models of the most important suspected links in guiding experimental and statistical work, in order to minimize the bias of estimates. Within the conceptual models the definition and measurement of variables as proxies for the previously discussed conceptual variables are of critical research importance. Among the biological variables that characterize health and nutrition inputs and status, those that have a likely causal relationship to fertility are the ones in which we are interested. The validity and reliability of alternative measures of nutritional and health status are the subjects of a vast literature and are beyond the scope of this paper. Likely candidates for measures of health and development status in most of the developing countries, however, are birth weight, mortality rates, weight by age, and simple anthropometric ratios based on height, head circumference, chest circumference, and circumference of upper arm. Different measures are best for children of different ages. For many evaluative purposes, neonatal, perinatal, infant, and child mortality rates (or mortality experience, in the case of individual families) are the best measures of health and nutritional status. Mortality can be measured and surveyed with relative ease and reliability, even retrospectively, and is highly correlated with morbidity and malnutrition. One drawback of mortality rates, however, is that they may fail to distinguish adequately among different levels of health, development, and nutrition in populations not suffering from severe malnutrition and morbidity. Another drawback is that both biological and behavioral mechanisms triggered by the death of a child can differ from the mechanisms arising from child morbidity and poor development. The death of a breast-feeding child may hasten the return of the mother's fecundity, while the death of any child may induce a shorter interval between births from replacement motives (see chapter 7).

Concerning lactation, both its duration and its intensity appear to be related to the length of the period of postpartum sterility. Therefore, the measurement of lactation should ideally include not only length but also simultaneous infant ingestion of other foods and frequency of suckling (Habicht and Behar 1974). The length of the period of lactation, however, is by far the most easily and reliably measured. The best empirical

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proxy for I , the interval between births, in the model of this paper would be the number of months between the outcome of a pregnancy and the next conception. The actual interval between births, measured from one pregnancy outcome to the next, is less satisfactory because its length depends on determinants of the next baby's survival in utero, as well as upon biological and behavioral factors associated with the previous child.

With regard to the behavioral variables of interest in these relationships, there is space here only to warn that empirical proxies that suffice in developed countries may be inadequate in less developed settings. For example, family income in less developed rural settings properly includes not only the value of agricultural and cottage-industry products, whether sold or consumed at home, but also the value of household production of goods and services for which markets are poorly developed, if they exist at all. Such services as child care, cooking, cleaning house, and cutting and carrying wood have value; they are often purchased in urban settings in the form of appliances and maid service. To disregard their existence in rural families biases statistics on rural income downward in relation to urban income. Further, the transfers of money, goods, and services that commonly occur among households and generations in societies lacking developed capital markets and institutionalized insurance and old-age security can make a family's annual disposable income quite different from its annual earnings.

Another behavioral concept difficult to measure accurately is the opportunity cost of a mother's time in child care. In many rural communities, work opportunities exist at home and elsewhere that interfere very little with child-care duties. Women desiring children will tend to choose these jobs, if any, while their children are young. The concepts of earnings, labor-force participation, and hours worked that have served economists and sociologists studying developed countries, therefore, require rethinking in the context of less developed countries.

General Conclusions

Of the known or suspected relationships among health and nutrition factors on the one hand and fertility outcomes on the other, considerably more is understood about biological links than about behavioral ones. For particular individuals, the biological dependencies of fecundity and fertility on nutrition, health, and lactation can vary a great deal. For groups of individuals, however, a negative relationship between health and nutritional status, and fertility measures clearly emerges. It is therefore clear that the behavioral factors are considerably more important at the population level.

EFFECTS OF NUTRITION AND HEALTH

Outlined earlier was an approach to understanding the health and nutrition behavior of poor people that emphasizes the reasonableness or rationality of their observed behavior and points to real changes in their economic incentives and constraints regarding health care and nutrition as the means to altering their behavior. Though the responses that people are hypothesized to make ultimately affect their health and nutrition, and therefore their fertility, largely through biological mechanisms, it is behavioral factors that bring these mechanisms into play.

If this picture is correct, technical assistance to families concerning the storing, preserving, and cooking of food may not succeed. In this case, the community has honed these techniques to perfection over the generations. In their own setting, the people know all the tricks that work. Likewise, instructing people in the nutritional needs of infants and children will contribute little. After generations of experiencing child mortality and morbidity, parents probably perceive these relationships in reasonably accurate terms, and allocative decisions are made accordingly. Similarly, decrying the feeding of nutritious crops to animals will not help. A family that made these suggested changes, if it had been in long-run equilibrium, would afterward be worse off in terms of its own preferences.

Instead, if this picture is correct, the solution is to introduce real changes in the environment in which allocative decisions are made. These may include new job opportunities that require a higher level of intelligence and physical stamina; a more efficient capital market supplying short-term credit at competitive rates; chemical fertilizers and agricultural technology that substitute for human labor and require instead allocative intelligence and schooling; and a local school in which well-nourished intelligent children perform better. Introducing these changes creates disequilibria, which in themselves place a premium on intelligence and schooling, and thereby on investments in childhood nutrition.⁴² Finding the points of effective intervention is the important task, and understanding the determinants of couples' *demand* for health- and nutrition-producing inputs and for children is the key. A "balanced approach," influencing many aspects of the environment simultaneously, is not likely to be as cost-effective as concentrating resources on particular crucial points of intervention.

The policy implications of this model obviously differ strikingly from those of the contender at the opposite extreme, the backward peasant model. Not only would the latter's recommendations not work in the world we have sketched; neither would the recommendations that we

⁴² Theodore W. Schultz (1964) emphasized the important role of education in dynamic settings. Finis Welch (1970) formalized this concept in a model of the allocative function of education and tested it.

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have outlined work in the other world, for people there are either too lazy, too ignorant, or too much bound by social norms and tradition to accept a good thing if it is new.

The evidence concerning adoption of new agricultural inputs and reallocation of land among crops in response to changing prices of inputs and outputs indicates clearly, by now, that peasant farmers in Asia, Latin America, and Africa can adjust quickly. There is a presumption that these same families would also adjust their allocation of food and other goods if their environments changed so as to make a response worthwhile, and if they were convinced that this was true. But the presumption remains untested, except that broad trends in patterns of food consumption during economic development seem consistent with it.

References

- Adelman, Irma, and Cynthia Taft Morris. 1968. "Performance Criteria for Evaluating Economic Development Potential: An Operational Approach," *Quarterly Journal of Economics* 82(2): 260-280 (May).
- Anker, Richard Bruce. 1973. "Socio-Economic Determinants of Reproductive Behavior in Households of Rural Gujarat, India." Ph.D. dissertation, University of Michigan.
- Austin, J. E., and F. J. Levinson. 1974. "Population and Nutrition: A Case for Integration," *Milbank Memorial Fund Quarterly* 52(2):169-184 (Spring).
- Baird, Dugald. 1965. "Variations in Fertility Associated with Changes in Health Status." In *Public Health and Population Change*. Pittsburgh: University of Pittsburgh Press.
- Berg, Alan (with Robert Muscat). 1973. *The Nutrition Factor: Its Role in National Development*. Washington, D.C.: Brookings Institution.
- Butz, William P. 1972. *Research and Information Strategies to Improve Population Policy in Less Developed Countries*. Santa Monica, Calif.: The Rand Corporation. R-952-AID.
- Correa, Hector, and Gaylord Cummins. 1970. "Contribution of Nutrition to Economic Growth," *The American Journal of Clinical Nutrition* 23(5):500-565 (May).
- Freedman, Deborah S. 1963. "The Relation of Economic Status to Fertility," *American Economic Review* 53(3):414-426 (June).
- Galenson, Walter, and Graham Pyatt. 1964. *The Quality of Labor and Economic Development in Certain Countries*. Geneva: International Labour Office.
- Gray, R. H. 1974. "The Decline of Mortality in Ceylon and the Demographic Effects of Malaria Control," *Population Studies* 28(2):205-229 (July).
- Griffith, D. H., D. V. Ramana, and H. Mashaal. 1971. "Contribution of Health to Development," *International Journal of Health Services* 1:253-270 (August).
- Habicht, Jean-Pierre, and Moises Behar. 1974. "Nutrición, planificación familiar y salud en la madre y en el niño," *Revista social pediatria El Salvador* 4(2):48-60.
- , and Robert Klein. 1972. "Possible Factors Affecting Acceptability of Fertility Regulation Methods in Four Guatemalan Ladino Villages." Paper presented at the WHO Task Force Symposium on Contraceptive Acceptability, Geneva, June 21-23.
- Jain, Anrudh K., T. C. Hsu, Ronald Freedman, and M. C. Chang. 1970. "Demographic Aspects of Lactation and Postpartum Amenorrhea," *Demography* 7(2):255-271 (May).
- Knowles, James C. 1970. "The Economic Effects of Health and Disease in an Underdeveloped Country." Ph.D. dissertation, University of Wisconsin.

REFERENCES

- Malenbaum, Wilfred. 1970. "Health and Productivity in Poor Areas." In *Empirical Studies in Health Economics*, edited by Herbert E. Klarman, pp. 31-54. Baltimore: Johns Hopkins University Press.
- Michael, Robert T. 1973b. "Education and Non-Market Production," *Journal of Political Economy* 81(2):306-327. (March/April).
- National Academy of Sciences. 1975. *Nutrition and Fertility Interrelationships: Implications for Policy and Action*. Washington, D.C.
- Perez, Alfredo, Patricio Vela, R. G. Potter, and G. S. Masnick. 1971. "Timing and Sequence of Resuming Ovulation and Menstruation after Childbirth," *Population Studies* 25(3):491-503 (November).
- . 1972. "First Ovulation After Childbirth: The Effect of Breast-feeding," *American Journal of Obstetrics and Gynecology* 114(8):1041-1047 (December).
- Pirie, Peter. 1972. "The Effect of Treponematoses and Gonorrhea on the Populations of the Pacific Islands," *Human Biology in Oceania* 1(3): 187-206 (February).
- Popkin, Barry M. 1972. "Report: Research Priorities. Unpublished. Methodologies Conference on Economics of Malnutrition, Office of Nutrition, Agency for International Development, Washington, D.C.
- Potter, R. G., M. L. New, J. B. Wyon, and J. E. Gordon. 1965. "Application of Field Studies to Research on the Physiology of Human Reproduction: Lactation and Its Effects Upon Birth Intervals in Eleven Punjab Villages, India." In *Public Health and Population Change*, edited by M. C. Sheps and J. C. Ridley. Pittsburgh: University of Pittsburgh Press.
- Reutlinger, Schlomo, and Marcelo Selowsky. 1975. "Malnutrition and Poverty: Magnitude and Target Group-oriented Policies." Working paper. Washington, D.C.: International Bank for Reconstruction and Development (IBRD).
- Salber, E. J., Manning Feinleib, and Brian MacMahon. 1966. "The Duration of Postpartum Amenorrhea," *American Journal of Epidemiology* 82(3):347-358.
- , J. J. Feldman, and M. Hannigan. 1968. "Duration of Postpartum Amenorrhea in Successive Pregnancies," *American Journal of Obstetrics and Gynecology* 100(1):24-29 (January 1).
- Schultz, T. Paul. 1974. *Fertility Determinants: A Theory, Evidence, and an Application to Policy Evaluation*. Santa Monica, Calif.: The Rand Corporation, R-1016/RF/AID.
- Schultz, Theodore W. 1964. *Transforming Traditional Agriculture*. New Haven, Conn.: Yale University Press.
- Siegel, Earl, and Naomi Morris. 1970. "Epidemiology of Human Reproductive Casualties, with Emphasis on Role of Nutrition." In *Maternal Nutrition and the Course of Pregnancy*, pp. 5-40. Washington, D.C.: National Academy of Sciences.
- Theil, Henri. 1971. *Principles of Econometrics*. New York: John Wiley and sons.

REFERENCES

- Welch, Finis. 1970. "Education in Production," *Journal of Political Economy* 78(1):35-59 (January/February).
- Wishik, Samuel M. 1972. "Nutrition, Family Planning, and Fertility." Paper presented at the Twenty-first Meeting of the Protein Advisory Group, United Nations, Paris, April.
- , Angus Thomson, and Jean-Pierre Habicht. 1972. "Drafts of Nutrition-Interaction Working Group." Geneva: WHO.
- , and Susan Van der Vynckt. 1973. "Uncontrolled Fertility and Malnutrition." Washington, D.C.: Committee on International Nutrition Programs, National Academy of Sciences.
- Wray, Joe D. 1971a. "The Malnutrition-Morbidity-Mortality (Triple-M) Complex in Pre-School Children." Working draft. New York: The Rockefeller Foundation.
- . 1975. "Does Better Nutrition Increase Fertility?" In Proceedings of the Ninth International Congress on Nutrition, Mexico. *Nutrition* 2:16-31.
- Wyon, John B., and John E. Gordon. 1971. *The Khanna Study: Population Problems in the Rural Punjab*. Cambridge, Mass.: Harvard University Press.